

# APPARATUS FOR AUTOMATIC MEASUREMENT OF MEASURING FIELDS

## Field of the Invention

The invention relates to a device for automatic measurement of measuring fields.

## Background of the Invention

The invention relates to a device for an automatic photoelectric measurement of measuring fields being provided on a sheet or strip type, opaque or transparent original. Such devices which are commonly named automatic strip readers are used, for example, in the photographic industry for a routine control of wet chemical device components on one hand and for the control of the settings of a photographic copy device (printer) on the other hand.

For the control of wet chemical device components, film or paper developing baths, respective film chemistry or paper chemistry strips are measured. These strips already underwent a standardized exposure at the respective film or copy paper manufacturer, and they contain a different arrangement of various measuring fields which differ from manufacturer to manufacturer. The operator of the wet chemical units develops the strips in more or less regular intervals in the respective film or paper developing units. The developed film or paper strips are photometrically analyzed using a hand densitometer or the mentioned automatic strip reader, whereby the determined measurement data are compared to the target data of the manufacturer. Depending on the determined comparative results, the developing baths are refreshed or filled up, renewed, or maintained unchanged. To control the settings of a photographic printer, one or several standard negatives are projected onto the photographic paper which is developed using a standardized and tested chemistry. The developed pictures are again photometrically analyzed and the determined measurement data are compared to the target data of the manufacturer. In dependence upon the determined comparative values, the settings of the printer can be corrected or maintained. Further details for this and examples for typical measurement strips are found in U.S. Patent No. 5,402,361 and U.S. Patent No. 5,118,183.

A strip reader of this kind is described in U.S. Patent No. 5,519,210. It includes a housing having an insertion slit arranged on its front side for a test strip – film or paper to be measured. A transport system is disposed within the housing in order to draw the supplied test strip in through the insertion slit and to advance it along a transport path and in doing so to guide it in a defined manner. In the vicinity of the transport path, a densitometric measurement arrangement is provided which can be operated in both,

transmission and remission mode, so that transparent (film) and opaque (paper) test strips can be equally measured. While the test strip is inserted, the measurement arrangement photoelectrically scans subsequent measuring fields in the direction of the transport path and transfers the electrical signals thus obtained to a controller which calculates digital measuring data therefrom which represent the (color) density of the scanned measuring fields on the test strip. In addition, the densitometric measurement arrangement is adjustable transverse to the transport direction of the test strip to allow the measuring of test strips having a two-dimensional array of measuring fields, so that the scanning can be carried out sequentially manner in several parallel tracks. The motion and function sequences are carried out under the control of the digital controller. Furthermore, a bi-directional interface connected to the controller is provided through which a data exchange with an external computer can occur, whereby the generated digital measuring data of the individual measuring fields of the test strip can be transferred to the external computer. In the case that the device is to be operated autonomously, it is additionally provided with a suitable keyboard and an optical display unit, which is connected to the controller and operates in concert with the same. After the measuring fields are measured, the test strip is ejected again through the insertion slit.

A further known strip reader is subject of U.S. Patent No. 5,402,361 and U.S. Patent No. 5,118,183. These devices are also equipped with densitometric measuring arrangements for the photoelectric measurement of the measuring fields contained on the control strip, but the densitometric measuring arrangements are not laterally adjustable so that the scanning of test strips with a two-dimensional measuring field arrangement is comparatively laborious and only possible by multiply inserting the test strip from the side in an off-set manner. The strip readers presented in these documents are connected to a telephone network by means of a suitable data interface and a modem, and furthermore are connected to a remote computer, for example a central quality control station. The remote computer can retrieve digital measuring data from the strip reader or, for example, can send control commands and messages to the strip reader, whereby the control commands trigger certain functions, and messages can be displayed, for example, on the display of the strip reader.

The densitometric analysis of the test strips which has been exclusively used to date in known strip readers is not sufficient in view of increased demands for quality in modern photographic production lines and color management. It is an object of the present invention to improve a device of the generic type in so far as to allow for a more

accurate and dependable analysis of the measuring fields of the test strips, so that better justice can be done to the demands and possibilities of modern photographic high quality production lines and that the device can also be particularly used for color management.

### **Summary of the Invention**

5 The solution of this object which forms the basis for the invention results from the features described in the characterizing portion of the independent claim.

The spectral measurement in accordance with the invention of the measuring fields allows a more accurate and objective evaluation of the same, which in turn allows a more accurate and better adjustment of the individual parts of the photographic production line.

10 The device is particularly suited for use in so-called color management, where measuring strips with very many measuring fields (far above 100) are used and colorimetrically measured with high precision.

In order to also measure very dense transparent originals, an additional densitometric measuring arrangement is provided in accordance with a preferred  
15 embodiment. This additional measuring arrangement makes the device more universally applicable.

In accordance with a further advantageous embodiment, the spectral measuring arrangement or the spectral and densitometric measuring arrangements are adjustable laterally to the direction in which the original moves. As a result, an automatic  
20 measurement of originals having two-dimensional measuring field arrangements is possible.

Further particularly advantageous embodiments and improvements of the device in accordance with the invention are the subject of the dependent claims.

### **Brief Description of the Drawings**

25 The invention will be further described in the following by way of the drawing wherein:

Fig. 1 shows a schematic longitudinal sectional view through the device in accordance with the invention;

Fig. 2 shows a strongly simplified schematic cross-sectional view which extends  
30 substantially along line II-II in Fig. 1;

Fig. 3 also shows a strongly simplified view of line III-III of Fig. 2;

Fig. 4 shows a block scheme of the most important components of the device and their integration into a network; and

Fig. 5 shows an exemplary original having measuring fields disposed thereon.

## Detailed Description of the Invention

As is apparent from Fig. 1, the device in accordance with the invention includes a housing 1 having a front side 2 on which an insertion opening in form of an insertion slit 3 is disposed. Above the insertion slit 3 there is a first exit opening in form of an exit slit 4. A second, also slit-shaped exit opening 6 is provided on the rear 5 of the housing 1. Between the insertion slit 3 and the first exit slit 4 is a guide channel 7 in form of a lying U which forms a transport path 8 for the original V to be measured, said original V being inserted into the housing 1 through the insertion slit 3. Motorically driven transport roller pairs 9 are arranged along the guide channel 7 or the transport path 8, wherein the original V is being drawn inside using the motor driven transport roller pairs 9 and is moved along the transport path in both directions. The transport roller pairs 9 are controlled by a controller 100.

The original V to be measured is manually inserted into the housing 1 through the insertion slit 3 and ejected through the first exit slit 4 by means of the transport roller pairs 9 after the measuring is completed. Alternatively, the original can also be ejected through the insertion slit 3, and in this case, the first exit slit 4 is not necessary anymore. In the case that there is sufficient space behind the housing 1 in practical applications, the original can also be ejected through the rear exit slit 6. For this reason, the housing 1 is provided with manually adjustable switching members of any type, not shown, which guide the original V either along the bent transport path 8 to the front exit slit 4 or directly to the rear exit slit 6. Naturally, also other guiding members defining the transport path 8 can be provided in place of the presented guide channel 7, for example. Furthermore, suitable guiding members are also provided at the side (in Fig. 1 acting in the direction perpendicular to the plane of the drawing) as in known strip readers, which are however not presented for reasons of clarity. The guiding members at the side are designed preferably for originals of varying width, for example as the described stepwise guiding ramps in United States Patent No. 5,519,210.

Fig. 1 presents four transport roller pairs 9. It is apparent, that for practical purposes more or less transport roller pairs can be provided. In one embodiment, the device is only equipped with one transport roller pair which is disposed immediately behind the scanning window 9a of the guiding channel 7. In this way, originals V which are too short to be ejected from one of the two ejection slits 4 or 6, are ejected again from the front through insertion slit 3.

Beside the U-shaped bend of the transport path 8, the device corresponds substantially to the device described in United States Patent No. 5,519,210 with respect to the guidance and the insertion or drive of the original to be measured, so that the person of skill in the art does not need a further detailed description in this regard.

5 The already mentioned scanning window 9a (in the presented embodiment) is provided in the direction of insertion of the original V just behind the first transport roller pair 9 in the guiding channel 7 (or in or between the other guiding members). The scanning window 9a extends transversally to the direction in which the original V is advanced (perpendicular to the plane of the drawing).

10 A spectral measuring arrangement 10 above the guiding channel 7 is that substantially consists of a detector 11 and a converter 12. The detector 11 includes a light source 13 of a known kind and various optical members (not presented), in order to guide the light coming from the light source 13 in a circular manner and at a standardized angle of incidence of about  $45^\circ$  onto the measuring fields of the original V which is guided  
15 through beneath the detector. Furthermore, the detector includes further optical members in order to receive measuring light (remitted or transmitted) at an angle of about  $90^\circ$  coming from a measuring field of the original V and to direct it to the converter 12. The latter mentioned optical members are symbolized in the drawing by a light guide 14. A particularly suitable detector of this kind is described, for example, in United States Patent  
20 No. 4,929,084.

The converter 12 is designed as a diode array spectrometer of a known kind and includes substantially a concave reflexion diffraction grating 15 and a linear field 16 of photosensitive diodes. The diffraction grating 15 locally splits the measuring light which it receives from the detector 11 via the light guide 14 in a wavelength-dependent manner.

25 The photo diode array 16 converts the spectrally split measuring light into respective electrical signals, so that the spectral components of the measuring light given off the scanned measuring field of the original are available in electronic form.

Spectral measurement arrangements of this and similar construction are common in modern spectrophotometers and are described, for example, in detail in United States  
30 Patent No. 5,040,889, United States Patent No. 4,929,084, and EP-B-0 489 286, so that no further explanation is necessary for the person skilled in the art.

In accordance with an advantageous aspect of the invention, an additional light source 17 is provided below the detector 11 on its optical axis so that the spectral measurement arrangement 10 can also measure transparent originals, wherein the light

source 17 illuminates the original or the measuring fields contained thereon from below. The measuring light transmitted from the transparent original V is in turn captured again by detector 11 and supplied to the converter 12. It is apparent, that in the case of transparent originals V, the light source 13 in detector 11 is not activated.

Furthermore, controller 100 as already mentioned and realized through a digital computer system is provided in housing 1 for the control of all motion and function sequences of the device. Controller 100 is connected in particular with the converter 12 or the photo diode array 16 contained therein, whereby it processes the generated electrical signals into corresponding digital measuring data, as is known from digital spectrophotometers (compare for example U.S. Patent No. 5,040,889). The interaction of the controller 100 with the remaining components of the device is explained further down below with respect to Fig. 4.

Transparent originals (film strips) are often optically dense, so that there is not sufficient light available for a spectrophotometric evaluation. In accordance with a further important aspect of the present invention, a densitometric measurement arrangement 20 is provided in addition to the spectral measurement arrangement 10 for allowing the measurement of such dense originals. The densitometric measurement arrangement 20 is placed, for example, directly adjacent to the spectral measurement arrangement 10, as is shown in Figures 2 and 3.

The densitometric measurement arrangement 20 is conventionally constructed, for example as is described in detail in U.S. Patent No. 5,519,210. It comprises a similar detector 21 as in the spectral measurement arrangement 10 and a converter 22 optically connected thereto. The converter 22 generates electrical signals by means of densitometric filters and photoelectric converters, wherein the electrical signals correspond to the intensities or densities of the measuring light originating from the original in the three classic spectral ranges red, blue, and green. The converter 22 can also be arranged directly below the detector 21. A light source 23 for illuminating the original from below is arranged below the detector 21 for the densitometric transmission measurement, similar as in the spectral measurement arrangement 10. If the densitometric measurement arrangement 20 is only used for through-light measurements, the light source in the detector is of course obviated. Like the spectral measurement arrangement 10, the densitometric measurement arrangement 20 is connected to the controller 100, whereby the latter processes the generated electrical signals in a known manner into

corresponding digital measuring data which represent the densitometric color densities of the scanned measuring fields on the original.

Film and paper chemistry strips and especially the measuring strips that are used in color management, often have a two-dimensional arrangement of measuring fields. In order to be able to also automatically measure such originals without elaborate manipulations, both measurement arrangements 10 and 20 are motorically adjustable transverse to the direction of transport of the original V (in Fig. 1 thus perpendicular to the plane of the drawing), in accordance with a further important aspect of the invention. This adjustability or the adjustment members required therefore are symbolized by a double arrow 30 in Figures 2 and 3. Naturally, the light sources 17 and 23 are thereby also adjustable together with the measurement arrangements, so that the relative positions of the light sources to their respective detectors remain the same.

The adjustment of the measurement arrangements 10 and 20 and the associated light sources 17 and 23 is realized by two motor drives 31 and 32 (Fig. 4) under control of the controller 100. Naturally, four independent drives can be provided or a single common drive in combination with a respective kinematic coupling of the components to be moved.

In accordance with a further important aspect of the invention, the device is equipped with an integrated white reference field 40, which is arranged in the plane of the original in the vicinity of the right end of the moving track shown in Figures 2 and 3 of the measurement arrangements 10 and 20. This white reference field 40 is sought out and measured by the spectral measurement arrangement 10 in certain time intervals or, for example, after each measurement of an original. Using the (spectral) digital measuring data thus obtained, the controller 100 can then in a known manner, as described for example in EP-A-0 878 704, perform an automatic white calibration. If necessary, the white reference field 40 can also be used for the calibration of the densitometric measurement arrangement. Instead of the single white reference field 40, it is also possible to use several reference fields of different color or grey shades for the calibration, as is also described more closely in EP-A-0 878 704.

Fig. 4 is a block diagram showing the connection of the already mentioned components of the device with the controller 100 as well as various further components. The spectral measurement arrangement 10 and the densitometric measurement arrangement 20 are directly connected to the controller 100, whereby the necessary analog signal amplifiers which are commonly contained within converter components, are not

presented. The analog/digital conversion occurs in the controller 100. The two light sources 17 and 23 are controlled by the controller 100 by way of respective lamp drivers 33 and 34. The motor drives 31 and 32 are also controlled by the controller 100 (by not shown driver stages). The transport roller pairs 9 for the advance of the original to be measured which are kinematically coupled to each other for example by means of a driving belt, are driven by a motor 35 which is controlled by the controller 100 by way of a not shown driver stage.

Further, the device can include a keyboard 51 and an optical display unit 52, which act in combination with the controller 100 in a known manner. The keyboard and the display unit, for example, can be omitted in the case of a device designed as a built-in unit.

Furthermore, the device is provided with a serial bi-directional data interface 53 and/or a USB interface 54, which are connected to controller 100 for allowing the communication of the device or its controller 100 with an external computer 500, for example, in a known manner. Digital measuring data can be transferred to the external computer via these interfaces in a known manner (for example, as described in U.S. Patent No. 5,402,361). Furthermore, the device can also be controlled by the external computer via these interfaces. The programming required therefore is known from modern digital spectrophotometers and hence does not require a detailed explanation.

Further, the device comprises an extension connection 55 for a network interface 56 or a modem 57 as well as a connection 58 for a bar code reader 59. The bar code reader allows, if necessary, to read data (Fig. 5) that are provided on the original V in form of a bar code BC to the controller 100.

Preferably, the network interface 56 and the modem 57 are designed as optional modules, which can be selectively connected to the device. Naturally, the network interface 56 and/or the modem 57 can also be permanently built-in to the device.

The network interface 56 (e.g. Ethernet) allows the connection of the device to a data network and thus the connection to an external computer, for example. By means of the modem 57 it is possible to make a connection to the external computer 500 via the public telephone network either directly or via the Internet 600 and vice versa. It is a prerequisite, of course, that the external computer 500 is also equipped with corresponding communication interfaces. The external computer 500 can, for example, belong to a central quality control location, where the digital measuring data that are generated with the device in accordance with the invention are analyzed. In doing so, it is of course, possible to connect further devices 200, 300, 400 in accordance with the invention to the



computer 500 via the Internet 600 (or the telephone net). It is apparent, that the access, if necessary, to the Internet is also possible via the network interface 56, when the network has an Internet-connection. The required software (programming of the controller 100) for the data communication via a data network and the Internet is known to a person of skill in the art and hence does not require a detailed explanation.


The respective functional sequences for the actual measurement of the original are substantially equal to the device known from United States Patent No. 5,519,210 for example.

The controller 100 stores the measuring field arrangements on the original for the most common types of originals in a suitable manner in assigning a notation or a code for the respective type of original. The data describing the measuring field arrangements are denoted in the following as (original) configuration data.

Before a measurement of the original can be performed, it is necessary to chose and adjust the respective type of original, for example, using the keyboard 51. In accordance with a particularly advantageous embodiment of the device in accordance with the invention, this selection can also be automatically performed by scanning the code of the type of the original which is contained on the original. This variant is explained in more detail further down below. Furthermore, the controller must be informed, for example by way of the keyboard 51 whether the original is an opaque or transparent original. Alternatively, this can be automatically determined by means of sensors known in the art. Finally, it needs to be determined and adjusted whether the measurement is to be performed spectrally or densitometrically. In accordance with the invention, this adjustment can also be performed automatically using controller 100 by measuring at least one measuring field and using the determined measuring data, for example, in connection with a density criterion.

For the measurement, the original V is inserted into the insertion slit 3 until it is taken over by the first transport roller pair 9 and then transported further by automatic control. If needed, the mentioned measurements for the identification of the type of original, the differentiation between opaque and transparent, and the determination between spectral or densitometric measurement are carried out first and the controller 100 is prepared accordingly. Alternatively, these prepared settings can be entered manually using keyboard 51, such as in U.S. Patent No. 5,519,210 for example.

Depending on the type of original and its configuration data, the controller 100 first transversely moves the appropriate measurement arrangement 10 or 20 into a



position, wherein the detector 11 or 21 (and the light source 17 or 23) are located above the first measuring field column. Now, the original is transported further inward until all measuring fields of the first column are measured. Subsequently, the measurement arrangement is moved to the next measuring field column using the configuration data of the original and the original is transported in a reverse direction until this column is also completely measured. This procedure is continued until all measuring fields of the original are measured. The digital measuring data thus obtained are temporarily stored in the controller 100 for further (internal or external) processing. Subsequently, the original is ejected again through one of the exit slits 4 or 6, or also through the insertion slit 3, as was described above. The obtained digital measuring data can be displayed in a suitable manner on the optical display unit 52. However, it is preferred that the data are transferred to the external computer via one of the communication interfaces, where the actual analysis of the data takes place. This is described in more detail further down below.

Fig. 5 shows an exemplary original V which has some exceptional features in comparison to common film and paper test strips and for which separate protection is sought.

The original V has a two-dimensional arrangement of measuring fields MF in the central region, which are adapted to the intended use of the original. Examples for typical measuring fields are shown in the already above-mentioned documents U.S. Patent No. 5,118,183 and U.S. Patent No. 5,402,361. The type of measuring fields and their arrangement on the original are characteristic for the respective type of original.

In each one of two diametrically opposed corners (in the example shown), there are four special measuring fields aligned one behind another in the longitudinal direction of the original V, wherein the field closest to the corner is a positioning field PF and the three other fields each represent a code field CF. The color of the fields is used as a coding information, wherein this is preferably limited to the primary colours red, blue, and green.

The positioning fields PF have different colours. Once the original is inserted into the device, the positioning field is the first field to be measured and its colour is determined in the controller using the measuring data. By using the colour, the controller 100 can then determine whether the original V was inserted into the device with its front edge (at the top in the drawing) or with its rear edge (at the bottom in the drawing).

The three remaining code fields CF through the combination of their colours respectively form a code for the type of the original. By limiting each code field to three colours, it is possible to distinguish between 27 different types of originals using three

code fields CF. If it is desired to have more original types, it is necessary to provide a respectively higher number of code fields CF or to allow more colours per field (preferably also visually reliably distinguishable).

The different codes for the type of originals are stored in the controller 100, as already mentioned, in relation to respective configuration data, which represent the arrangement of the measuring fields MF on the original. Naturally, the (predetermined) positions of the positioning fields PF and the code fields CF are also stored in the controller. When the original V is inserted into the device, the spectral measurement arrangement 10 (or alternatively also the densitometric measurement arrangement 20) is first laterally moved into such a position that the positioning field and the code fields can be scanned. Using the measuring data thus obtained, the colours of these scanned fields are determined and thus the positioning code and the code for the type of original. Using the code for the type of original, the configuration data (arrangement of the measuring fields MF) belonging to the respective type of original are chosen or retrieved from memory, whereby the insertion direction (front or rear edge) determined from the positioning code is taken into consideration accordingly. The controller knows the positions of the measuring fields MF to be measured on the original V, so that the measuring fields MF can be sequentially selected and measured.

The advantage of coding the type of original directly on the original is, that it is not necessary to provide the information regarding the type of original to the device (e.g. via the keyboard) so that the handling is simplified and entry errors are avoided. The positioning code also simplifies the handling since it is no longer necessary to pay attention that the original is inserted into the device in the correct orientation.

If the device is utilized for measuring originals employed in different production lines, then the measurement results must be assigned to the respectively correct production line. This can be done, for example, by manually entering a corresponding original identification code which is then assigned in the controller 100 to the measuring data of the respective original in form of original identification data. In accordance with a further important aspect of the invention, this original identification code can also be directly provided on the original itself and can be automatically read in from the original.

In the case of pre-exposed originals for the testing of chemical treatment baths, the code is preferably provided on the original in form of a bar code BC. The bar code can thereby be printed, for example, on a label that is glued to the original in a suitable

location. This original identification code can be read in by the controller using the already mention bar code reader 59.

Originals that are exposed within a printer for testing the same, have the original identification code exposed preferably directly onto the original in the printer. Naturally, the printer must be capable of doing this, which is however the case in modern digital printers. The exposed on code can be formed of a number of coloured code fields CF, similarly to the code for the type of original, and can be located on the original, for example in line with the code for the type of original. The original identification code is read by the controller 100 in the same manner as the code for the original type upon insertion of the original V into the device, whereby the controller 100 forms corresponding original identification data using the original identification code and subsequently assigns the determined digital measuring data to the measured original.

In the prior art devices described in the above cited documents U.S. Patent No. 5,519,210 and U.S. Patent No. 5,118,183, the digital measuring data of the measured originals are transferred to an external computer, wherein this computer can also be provided in a remote location and is then connected to the device via the telephone network. The transfer of the data is either initiated by the device or by the external computer. This process has the disadvantage, that a permanent connection for communication must exist between the device and the external computer.

In accordance with a further important aspect of the invention the device is designed to access the Internet and to store the digital measuring data on the Internet. This can be done for example using the known FTP (File Transfer Protocol), but is preferably carried out via e-mail. In doing so, the measuring data are processed together with the original identification data to yield a data file of an internationally standardized format IT8 and this data file is then sent as an attachment to an e-mail message to an e-mail address for this purpose. The data can then be retrieved therefrom through the external computer at any given time. Alternatively, the external computer can also deposit an e-mail destined for the device on the Internet, and the device can retrieve this e-mail at a certain point in time from the Internet. In this manner it is possible to send from the external computer to the device messages which can be optically displayed on the display unit of the device. Furthermore, it is also possible to transfer control and configuration data for the device into the device. The software required for the e-mail communication which is stored and run in the controller is standard nowadays and a person of skill in the art does not require an explanation therefor.